

A Review of Recent UAlbany CSTAR Research on Warm-Season Precipitation Systems Including Predecessor Rain Events Ahead of Tropical Cyclones

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1st NOAA Testbed USWRP Workshop
28 April 2009

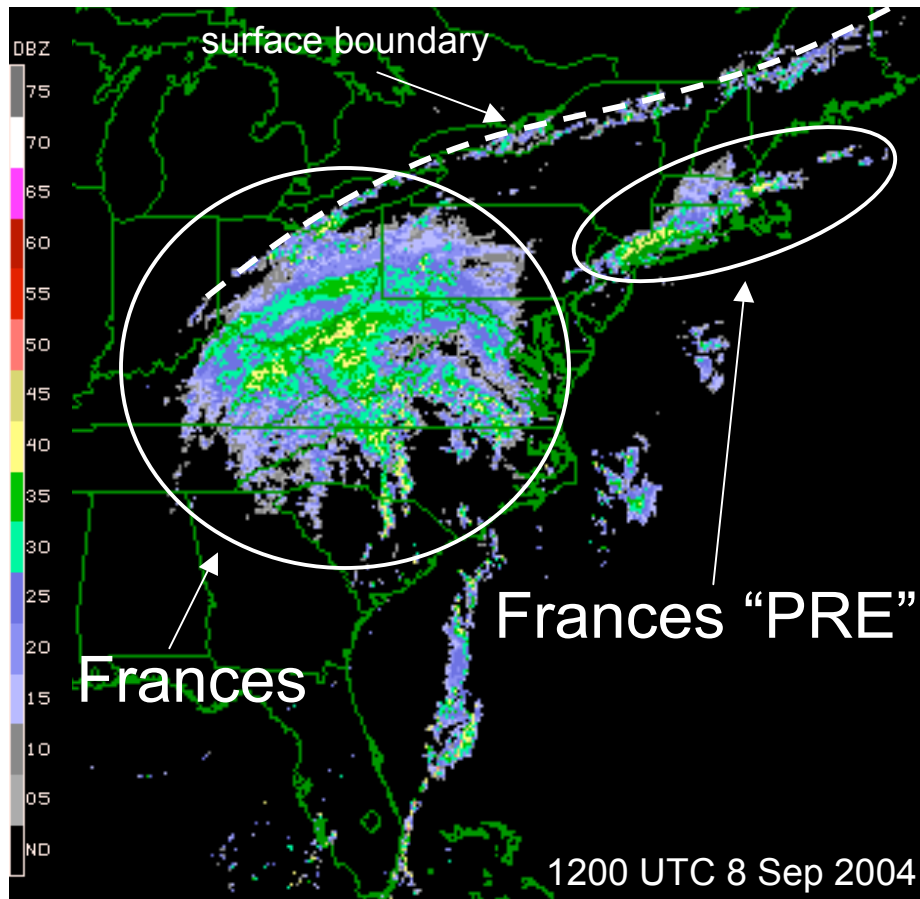
Recent UAlbany CSTAR Research

- Recent UAlbany CSTAR research addresses both cool- and warm-season heavy precipitation events and forecasting problems over the Northeast U.S.:
 - Warm-season lake-/sea-breeze severe weather
 - Warm- and cool-season precipitation distribution associated with cutoff cyclones
 - Cool-season severe convection and high-wind events
 - Warm-season precipitation associated with recurving and landfalling tropical cyclones (TCs), including predecessor rain events (PREs)

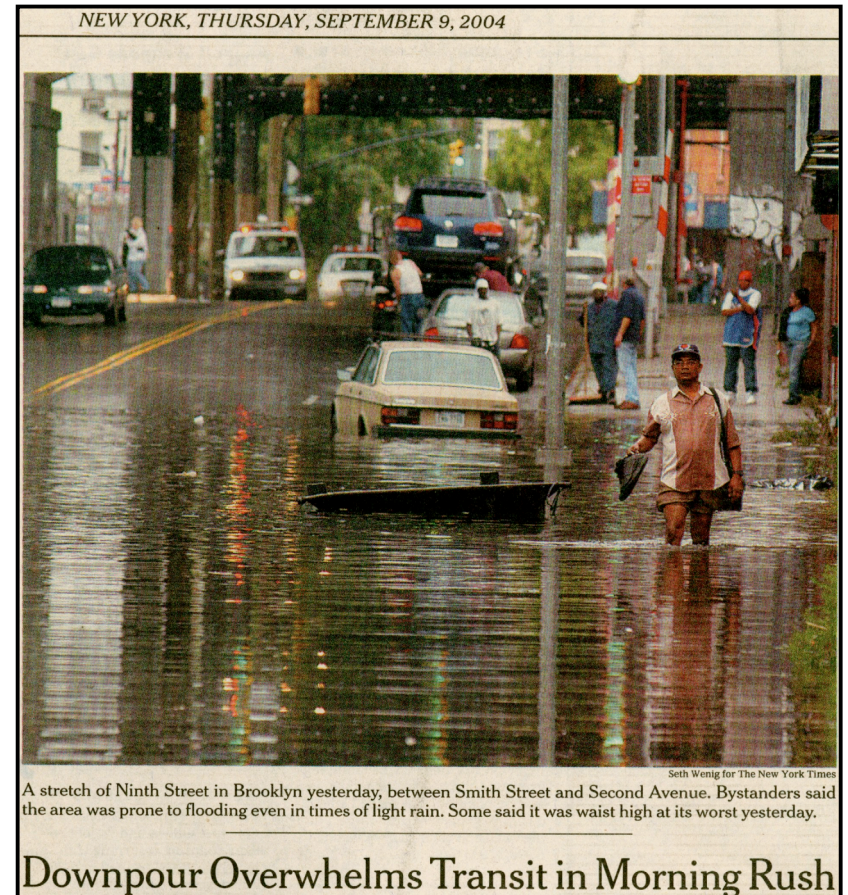
Recent UAlbany CSTAR Research

- The most up-to-date information—including presentations, theses, and teletraining sessions—can be found on the UAlbany/NWS CSTAR research webpage
 - <http://cstar.cestm.albany.edu>

PREs Associated with Recurving TCs



Reflectivity composite from
NCAR case selection archive



Article from the front page
of the *NY Times* 9 Sep 2004

High-Impact TC Frances PRE on 8 Sep 2004

Motivation

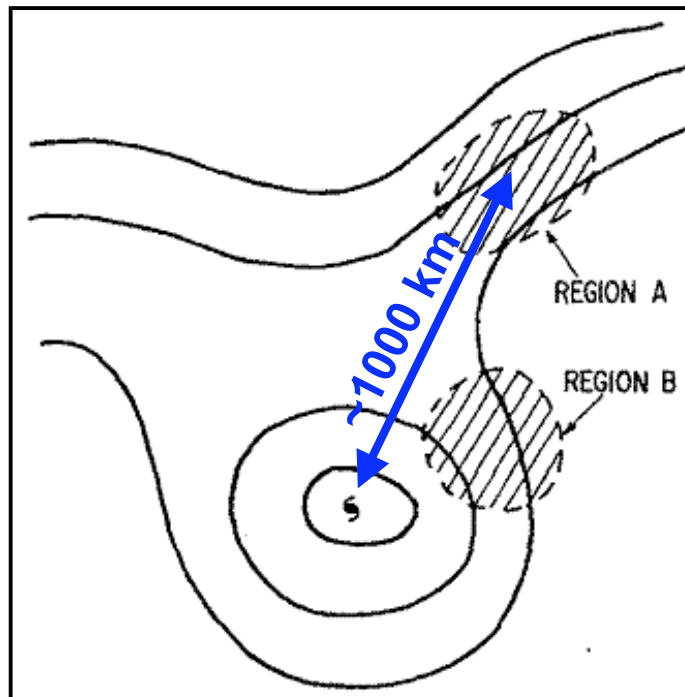
- PREs are high-impact weather events that frequently result in significant inland flooding
- High-impact PRE occurred with Tropical Storm (TS) Erin on 19 Aug 2007
- Band of heavy rain (>250 mm) over the northern Great Plains and Great Lakes region on 19 Aug associated with Erin moisture

Outline

- Definition of PRE
- Case analysis of TS Erin PRE
- Concluding remarks

Predecessor Rain Events (PREs)

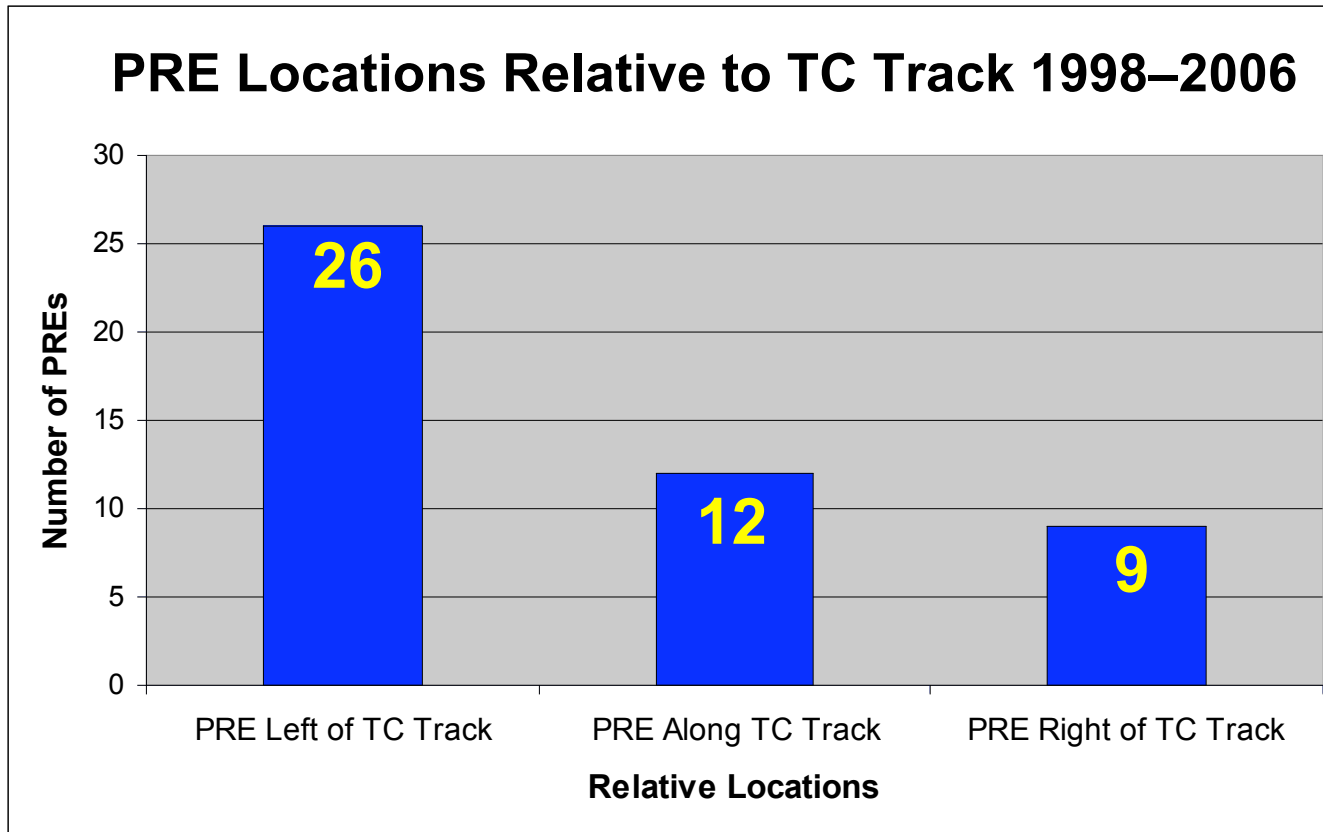
- Coherent area of rain displaced poleward of TC
- Moisture transport from TC toward PRE
- Event duration ~ 12 h
- Maximum rainfall rates typically ≥ 100 mm $(24 \text{ h})^{-1}$
- Time lag between PRE and TC passage ~ 36 h



Bosart and Carr (1978) conceptual model of antecedent rainfall for TC Agnes (1972)

Detailed study of PREs in Cote (2007)

PRE TRACK-RELATIVE POSITIONS



47 PREs associated with 21 TCs were identified (~2 PREs per TC)

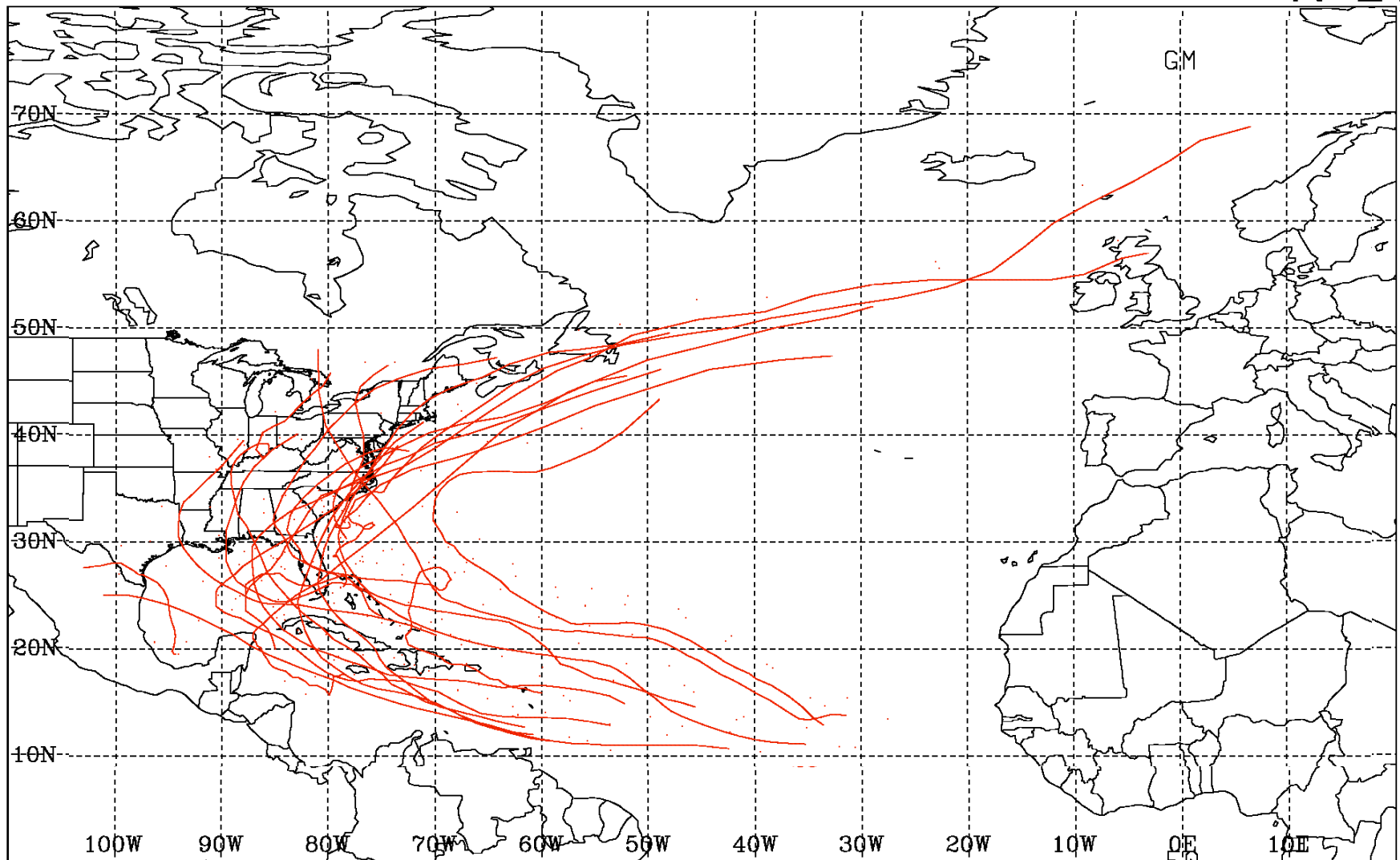
~1/3 of all U.S. landfalling TCs produced at least one PRE

Five cases where TC did not make U.S. landfall

Cote (2007)

PRE Parent TC Tracks 1998–2006

N=21



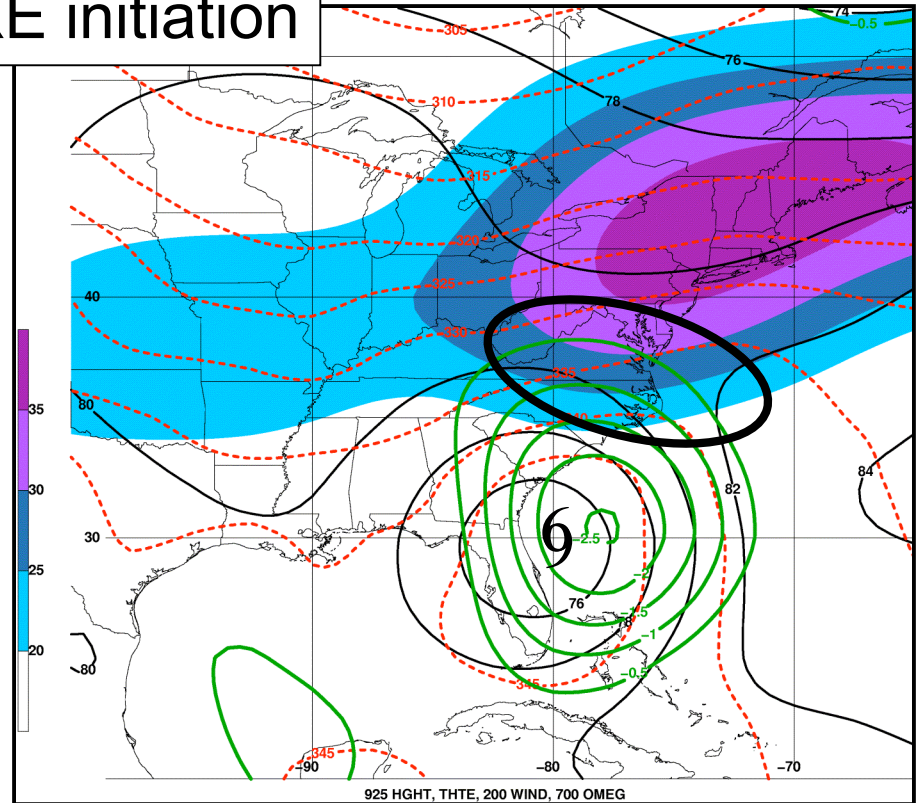
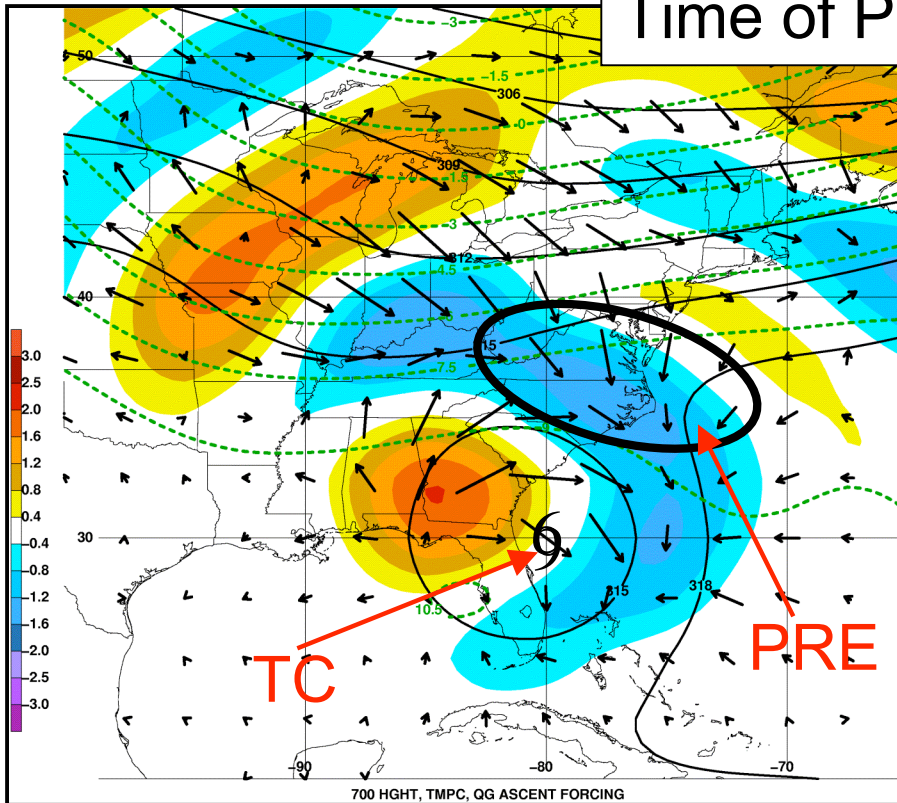
TC-Relative Composite for PREs

1998–2006

N=21

$$\bar{Q} = \left(-\frac{\partial \bar{V}_g}{\partial x} \cdot \nabla_p \theta, -\frac{\partial \bar{V}_g}{\partial y} \cdot \nabla_p \theta \right)$$

Time of PRE initiation



700-hPa h (dam), T (°C),
Q (10^{-12} K m $^{-1}$ s $^{-1}$),
 $\nabla \cdot \mathbf{Q}$ (10^{-16} K m $^{-2}$ s $^{-1}$)

2.5° NCEP–NCAR Reanalysis

925-hPa h (dam), θ_e (K),
 700-hPa upward motion
 (10^{-3} hPa s $^{-1}$),
 200-hPa wind speed (m s $^{-1}$)

TS Erin PRE 18–19 Aug 2007

Case Analysis



Photo from Minneapolis *Star Tribune*

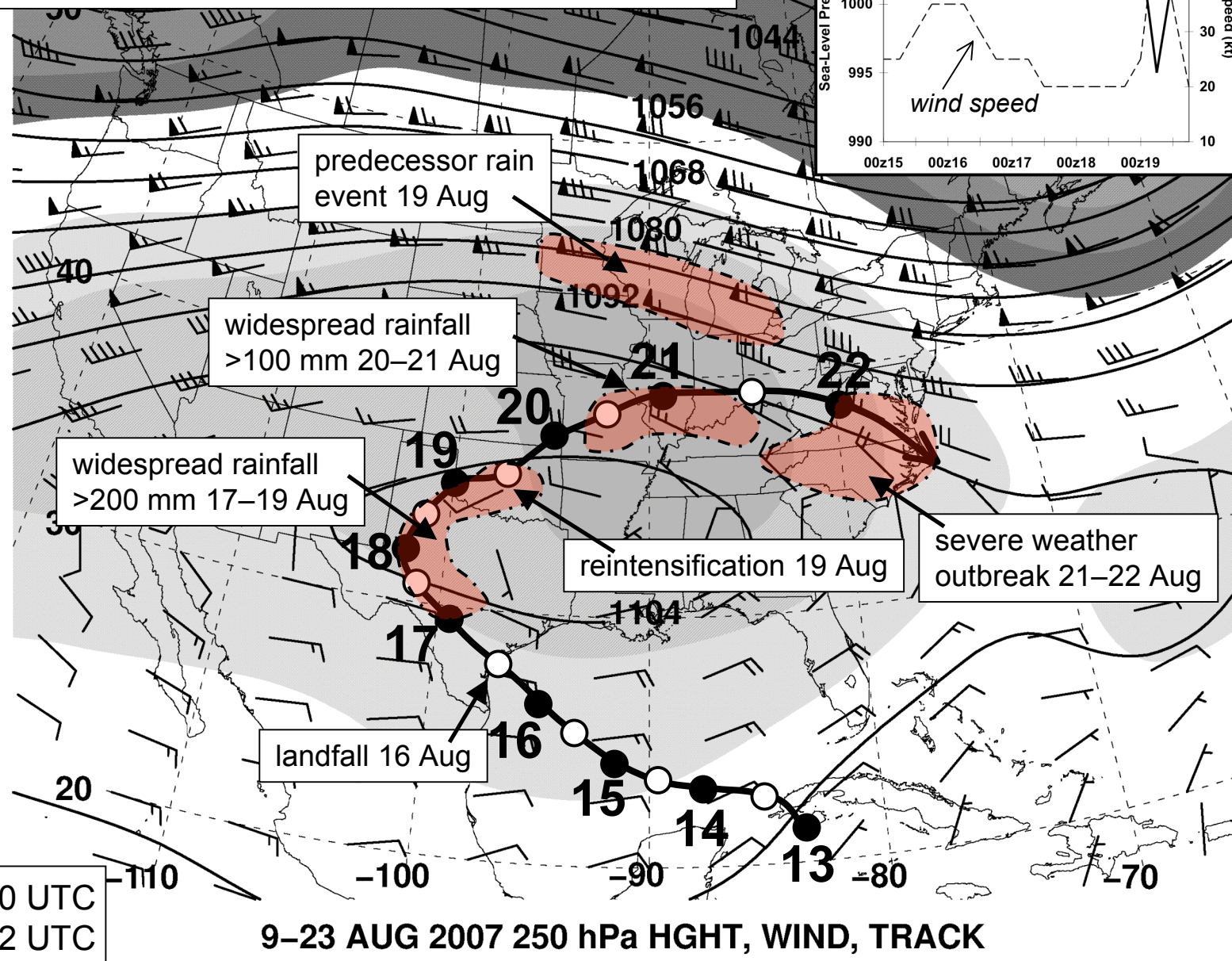
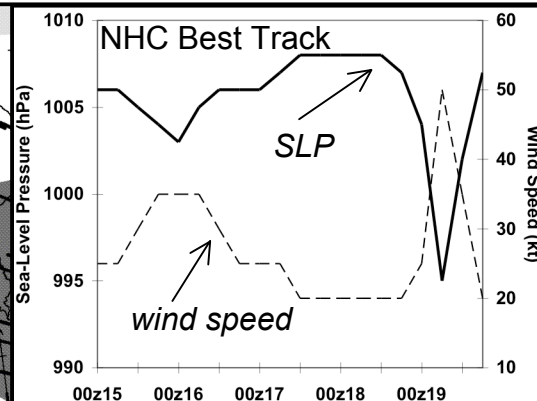


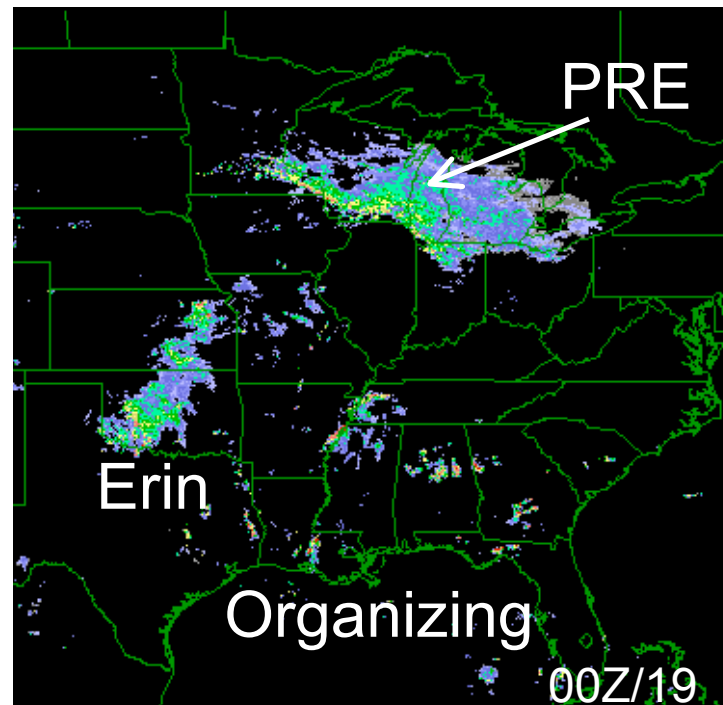
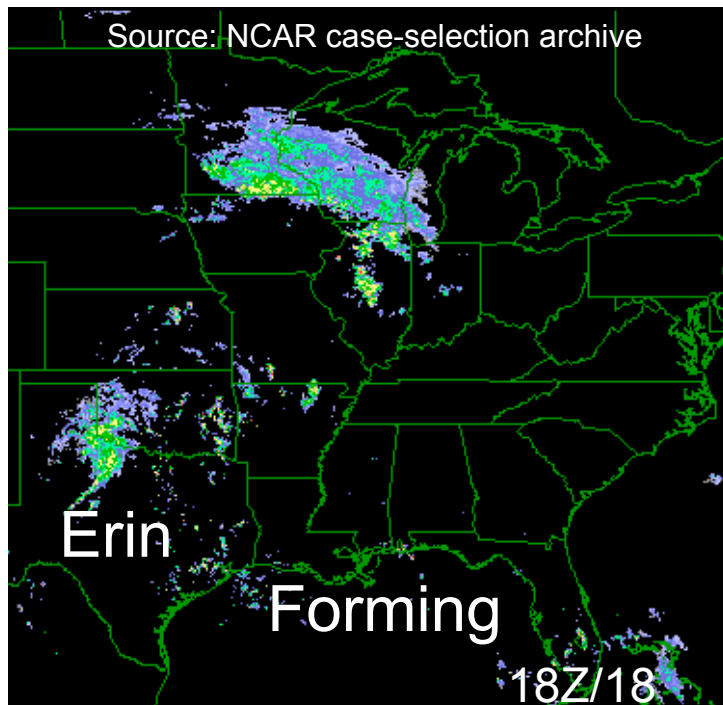
Photo from NWS La Crosse, WI

Datasets for Case Analysis

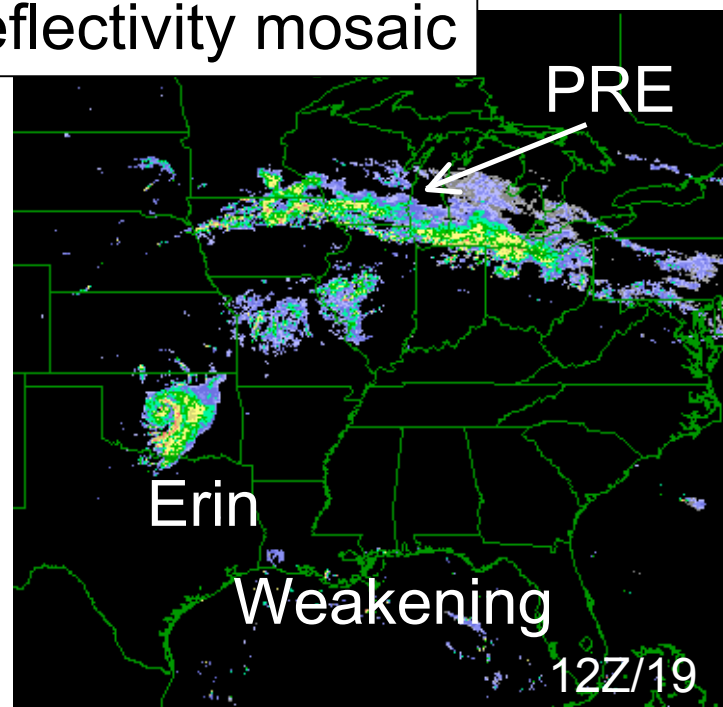
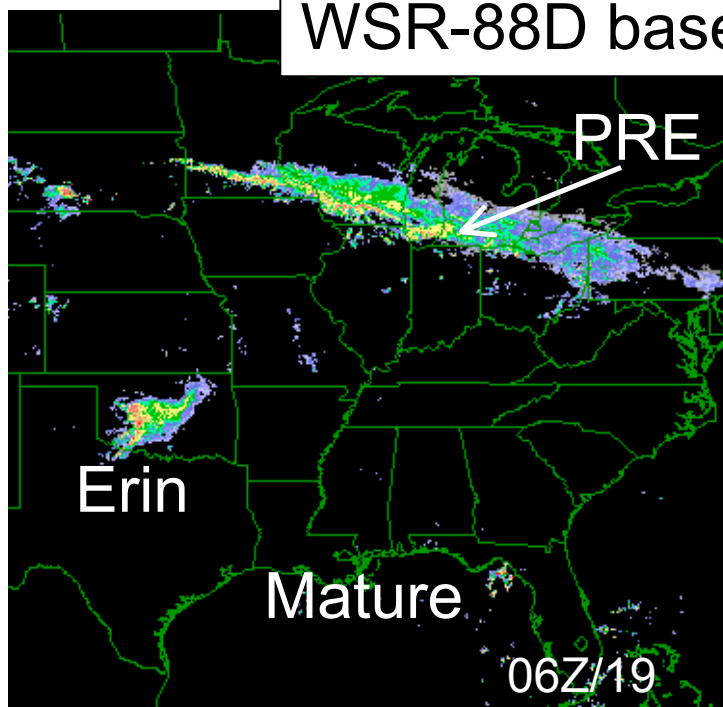
- 0.5° NCEP GFS analyses
- 2.5° NCEP–NCAR reanalysis
- Radar imagery from NCAR case selection archive
- Soundings and surface data from UALB archive
- Precipitation data from the National Precipitation Verification Unit, NCDC ASOS archive, and the Weekly Weather and Crop Bulletin
- Air parcel trajectories computed from NOAA HYSPLIT model webpage

250-hPa mean and anomaly height (dam),
wind barbs (kt), and TS Erin track
9–23 Aug 2007

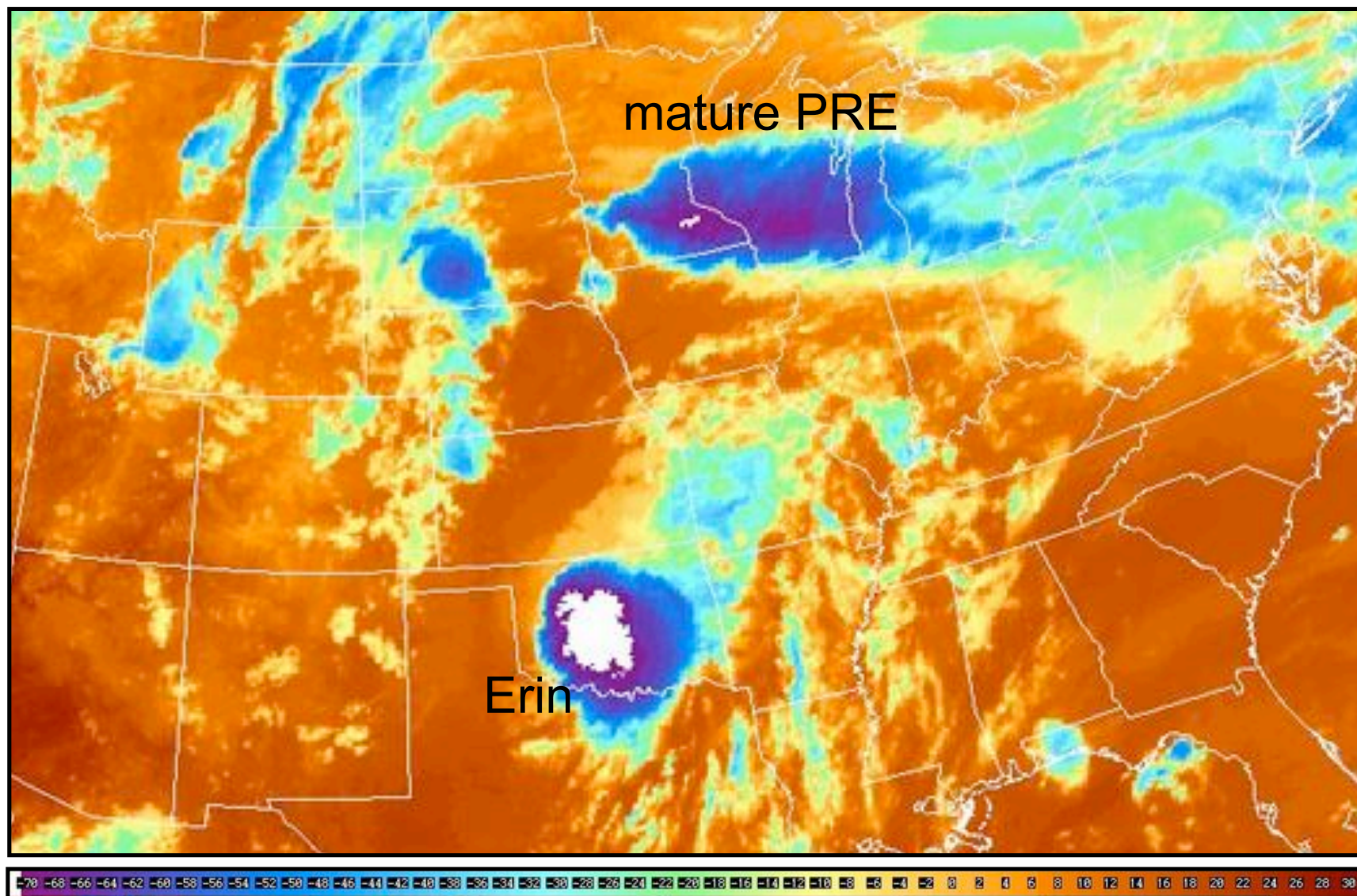




WSR-88D base reflectivity mosaic

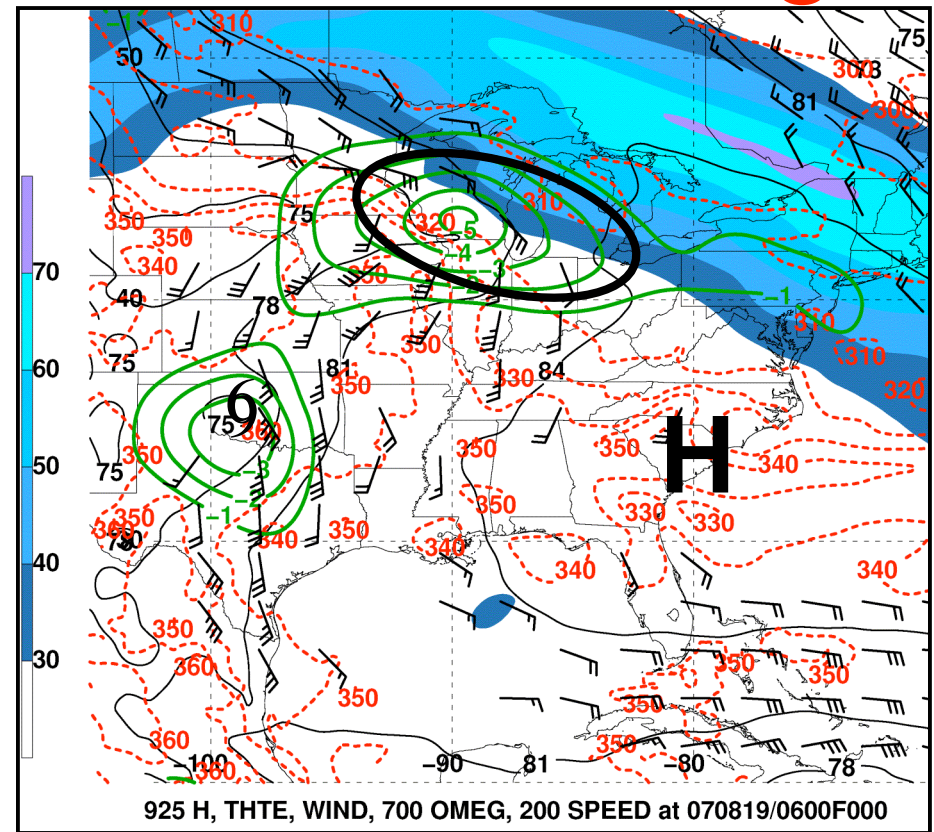
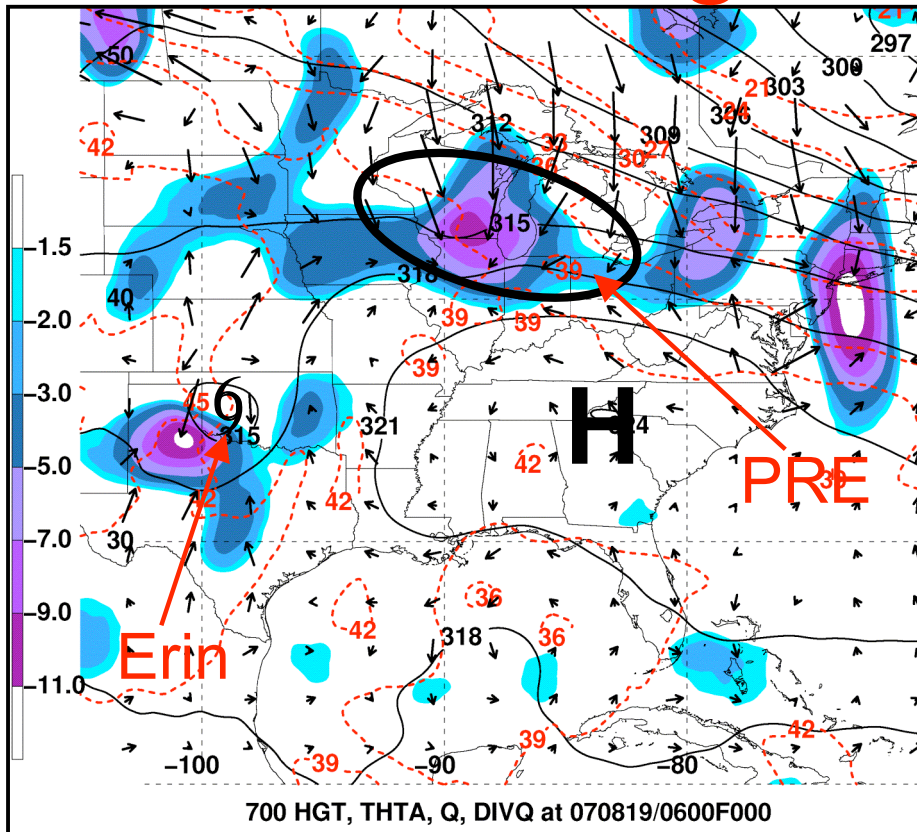


GOES-12 Infrared Image at 0600 UTC 19 Aug



Source: NCAR case selection archive

Synoptic Analysis during PRE Mature Stage 0600 UTC 19 Aug

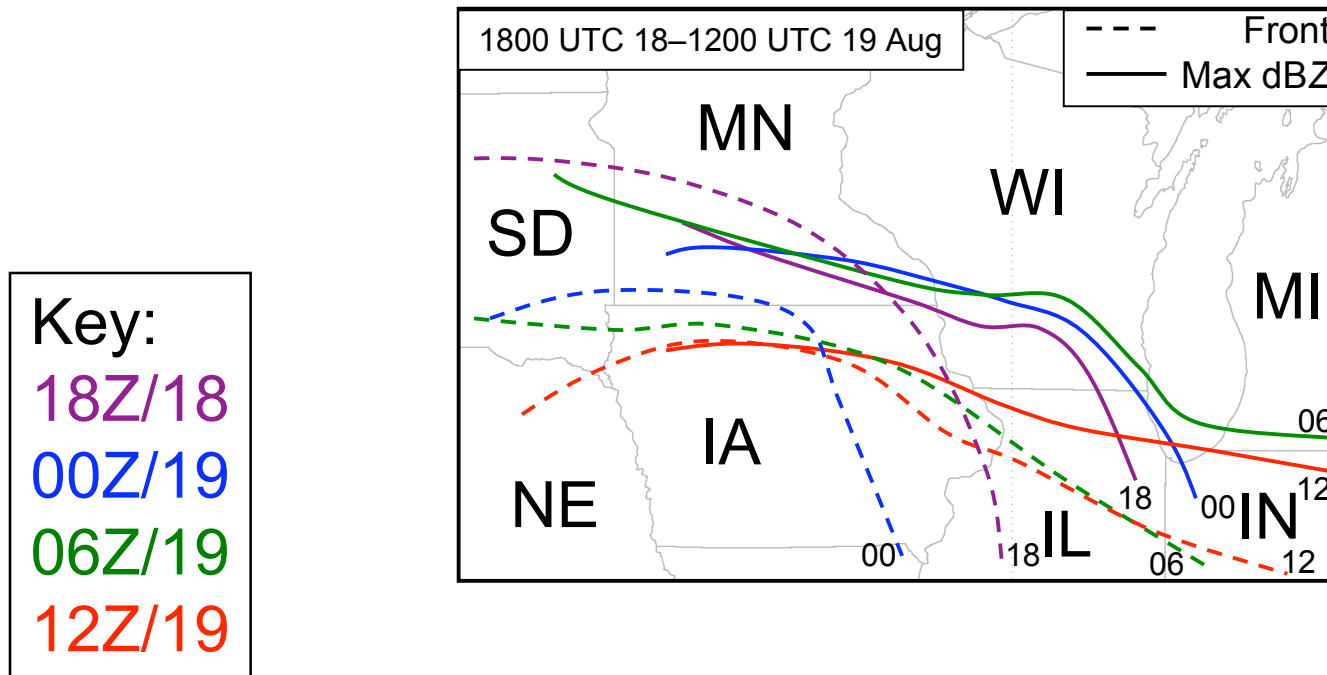


700-hPa h (dam), θ ($^{\circ}\text{C}$),
 Q ($10^{-12} \text{ K m}^{-1} \text{ s}^{-1}$),
 $\nabla \cdot \mathbf{Q}$ ($10^{-16} \text{ K m}^{-2} \text{ s}^{-1}$)

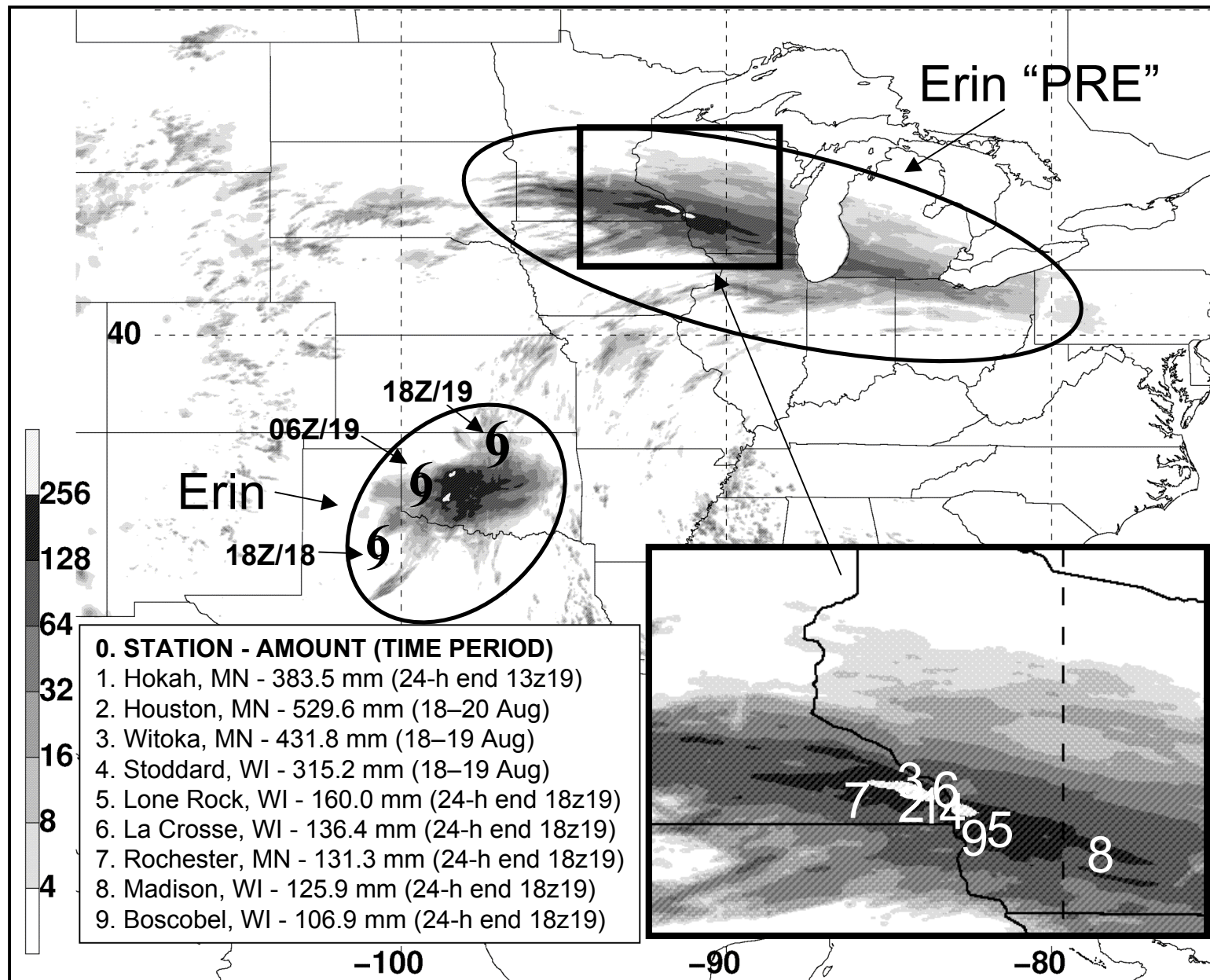
$$\bar{Q} = \left(-\frac{\partial \bar{V}_{nd}}{\partial x} \cdot \nabla_p \theta, -\frac{\partial \bar{V}_{nd}}{\partial y} \cdot \nabla_p \theta \right)$$

925-hPa h (dam), θ_e (K), wind (kt),
 700-hPa upward motion
 ($10^{-3} \text{ hPa s}^{-1}$),
 200-hPa wind speed (m s^{-1})

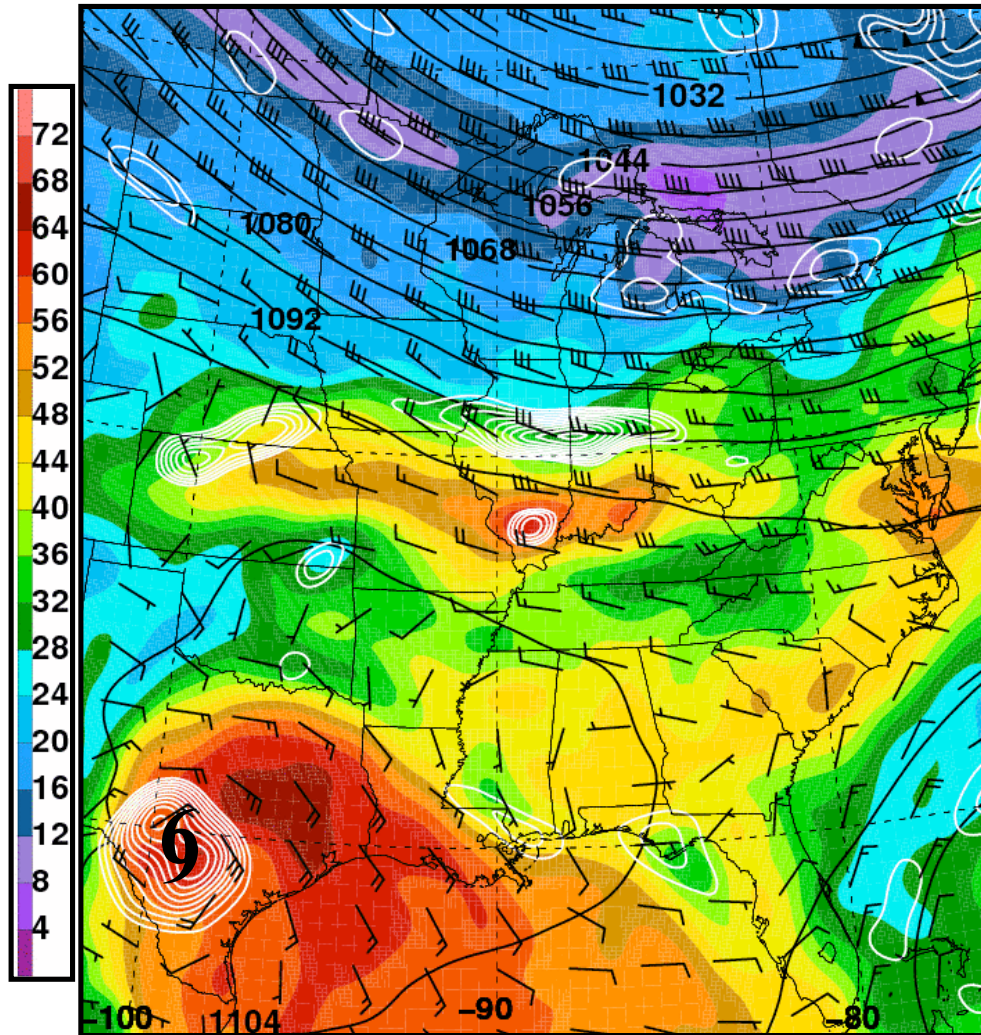
Isochrone Analysis of Surface Frontal Position and Maximum dBZ 1800 UTC 18–1200 UTC 19 Aug 2007



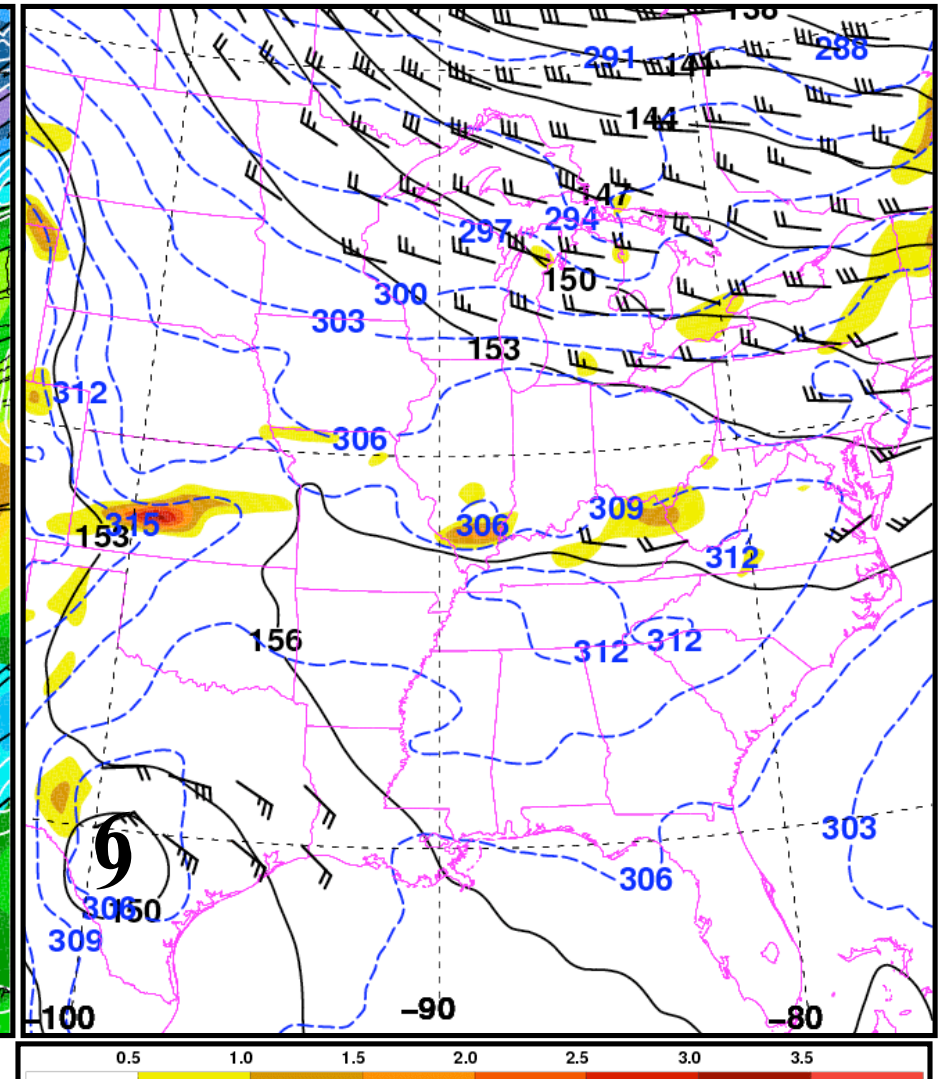
Total Precipitation (mm) 1800 UTC 18–1800 UTC 19 Aug 2007



250 hPa ω (dam), 700 hPa ζ (10^{-5} s^{-1}),
precipitable water (mm)
850–500 hPa mean wind (kt)

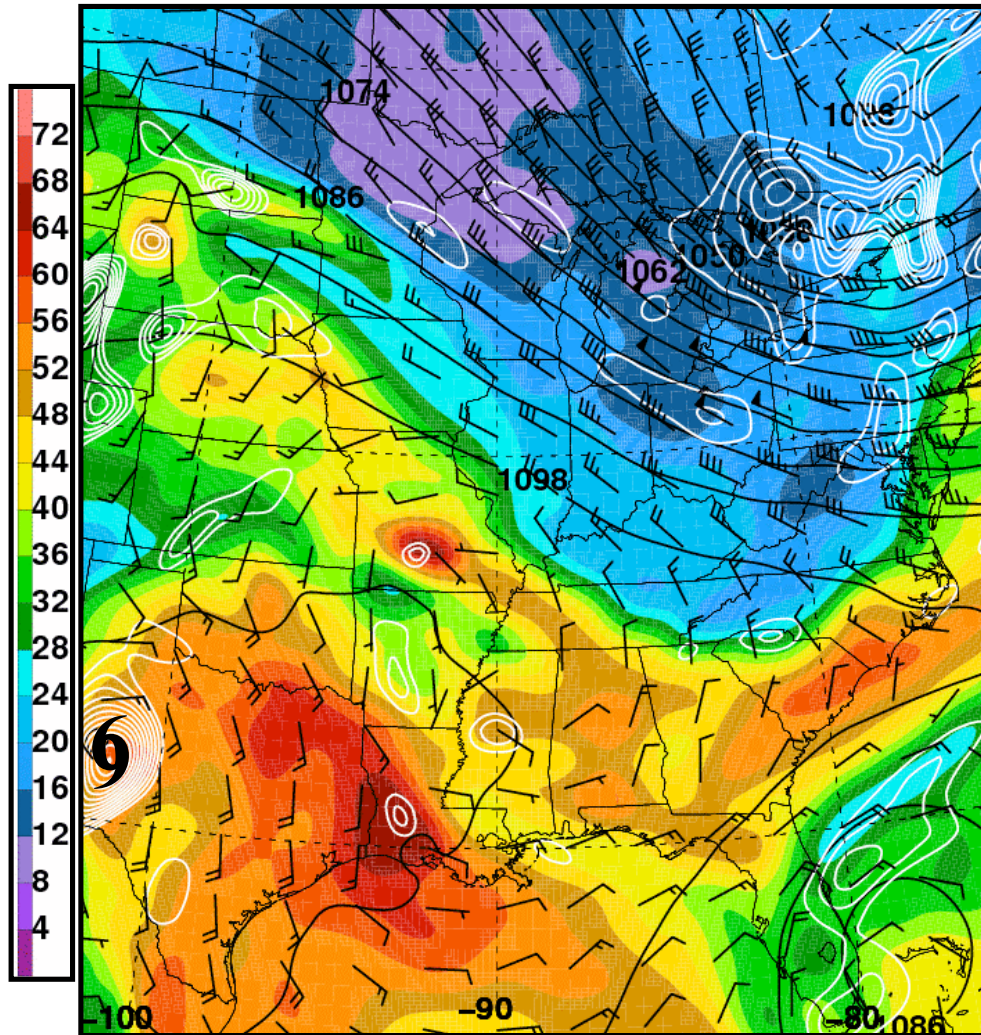


850 hPa ω (dam), θ (K), wind (kt)
900–800 hPa frontogenesis
[$\text{K (100 km)}^{-1} (3 \text{ h})^{-1}$]

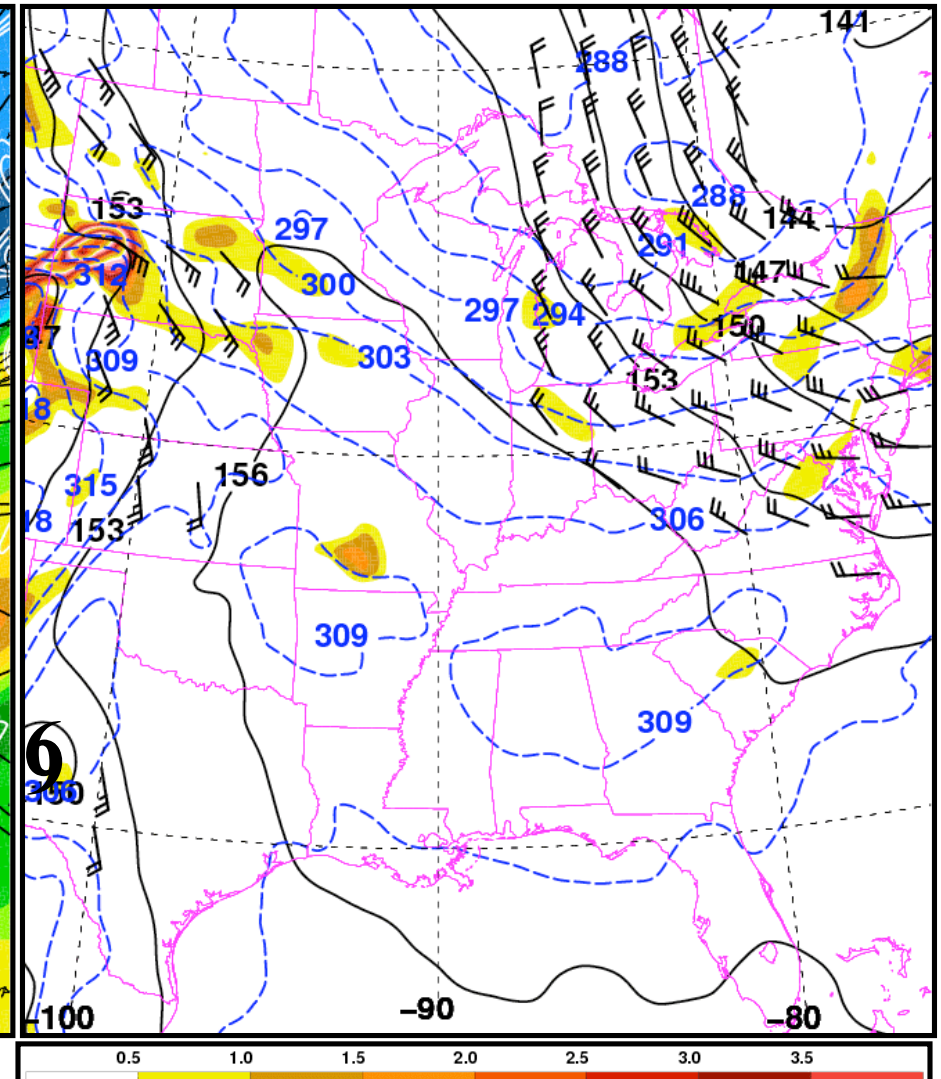


0000 UTC 17 Aug 2007

250 hPa h (dam), 700 hPa ζ (10^{-5} s^{-1}),
precipitable water (mm)
850–500 hPa mean wind (kt)

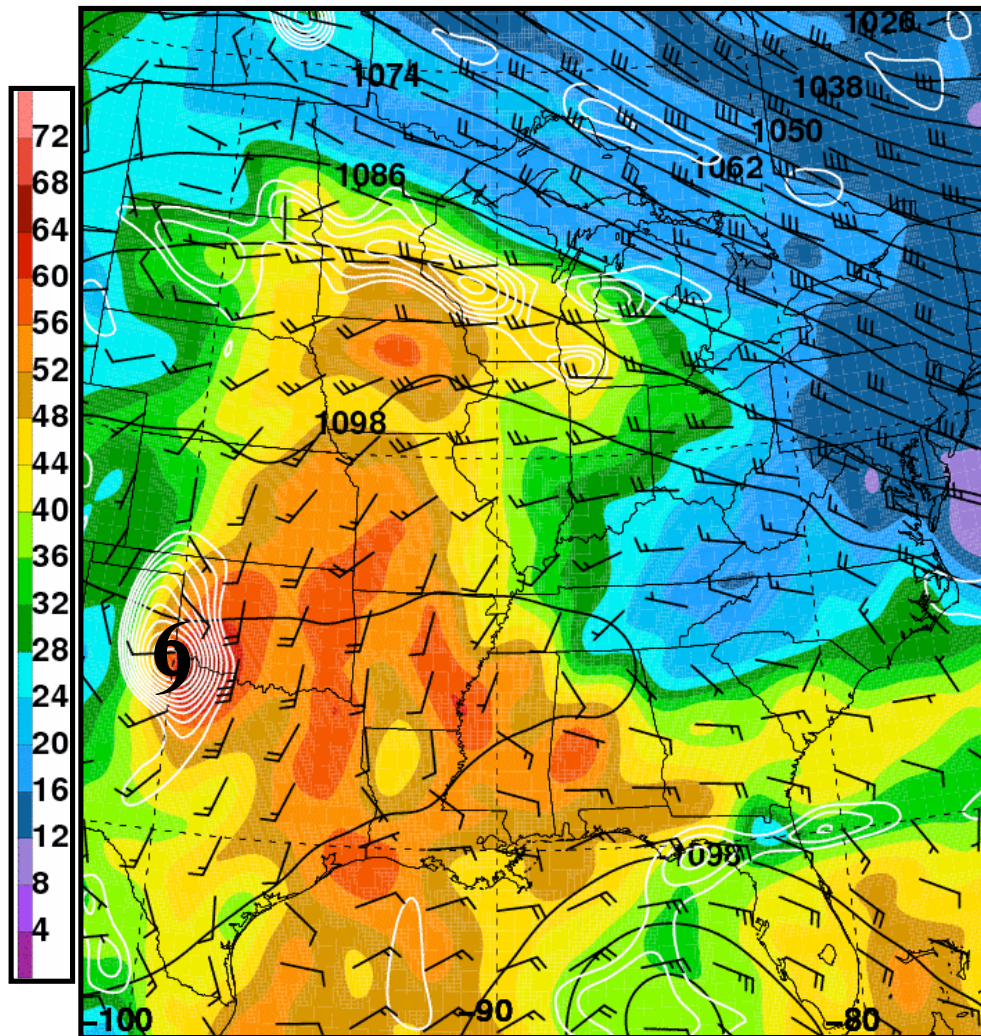


850 hPa h (dam), θ (K), wind (kt)
900–800 hPa frontogenesis
[$\text{K (100 km)}^{-1} (3 \text{ h})^{-1}$]

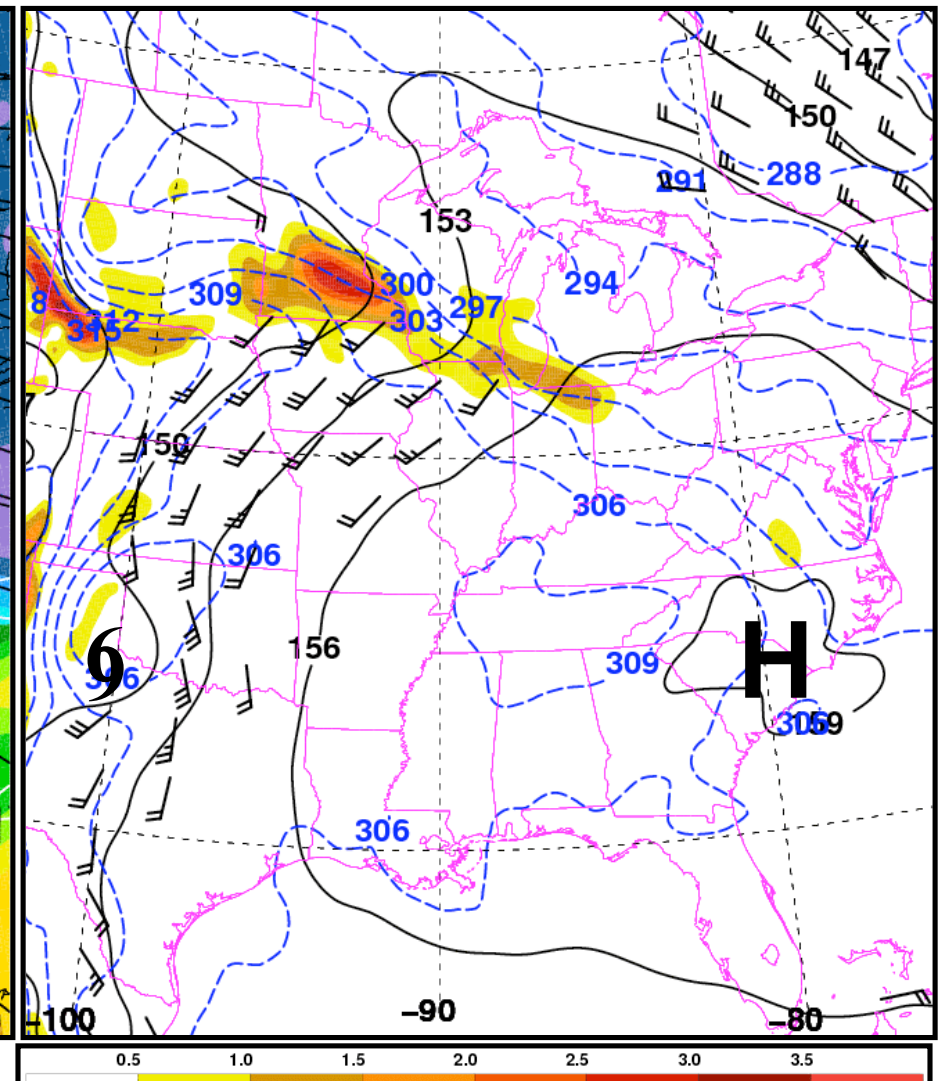


0000 UTC 18 Aug 2007

250 hPa ω (dam), 700 hPa ζ (10^{-5} s^{-1}),
precipitable water (mm)
850–500 hPa mean wind (kt)

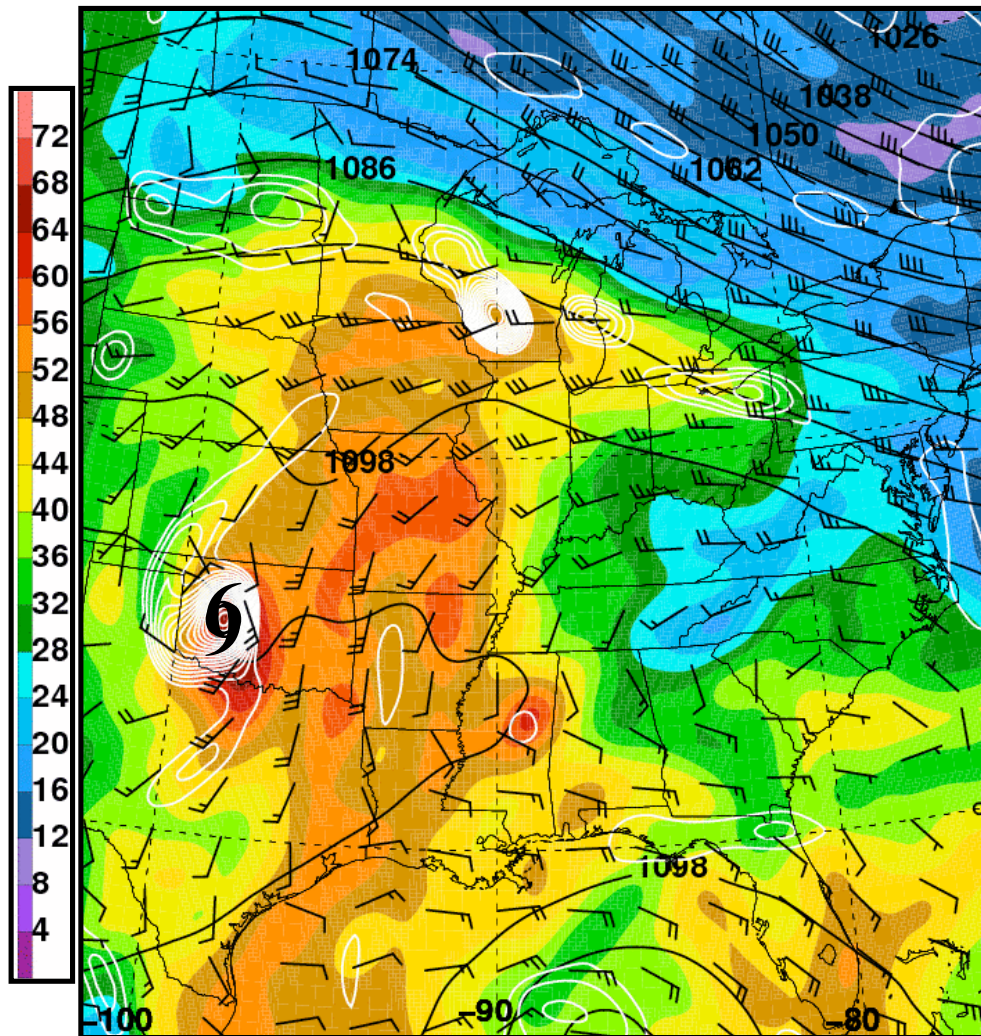


850 hPa ω (dam), θ (K), wind (kt)
900–800 hPa frontogenesis
[$\text{K (100 km)}^{-1} (3 \text{ h})^{-1}$]

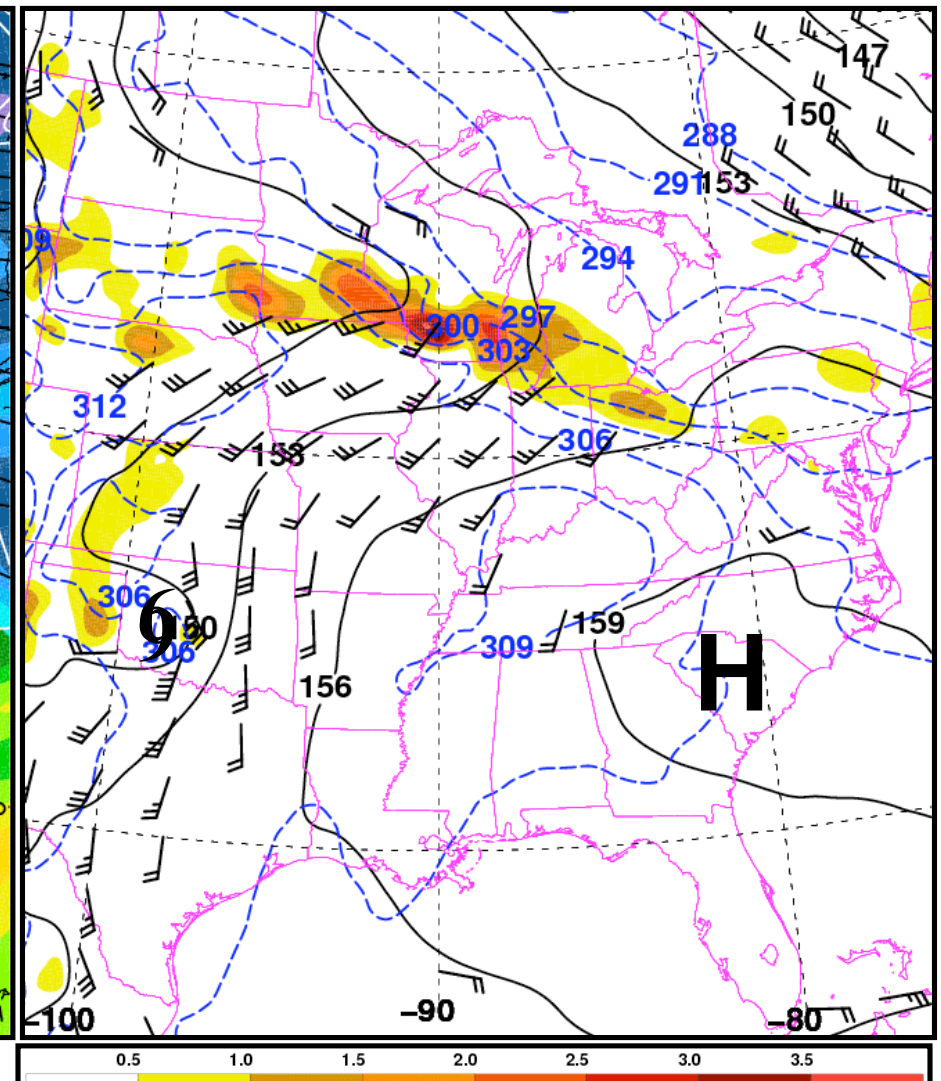


0000 UTC 19 Aug 2007

250 hPa ω (dam), 700 hPa ζ (10^{-5} s^{-1}),
precipitable water (mm)
850–500 hPa mean wind (kt)

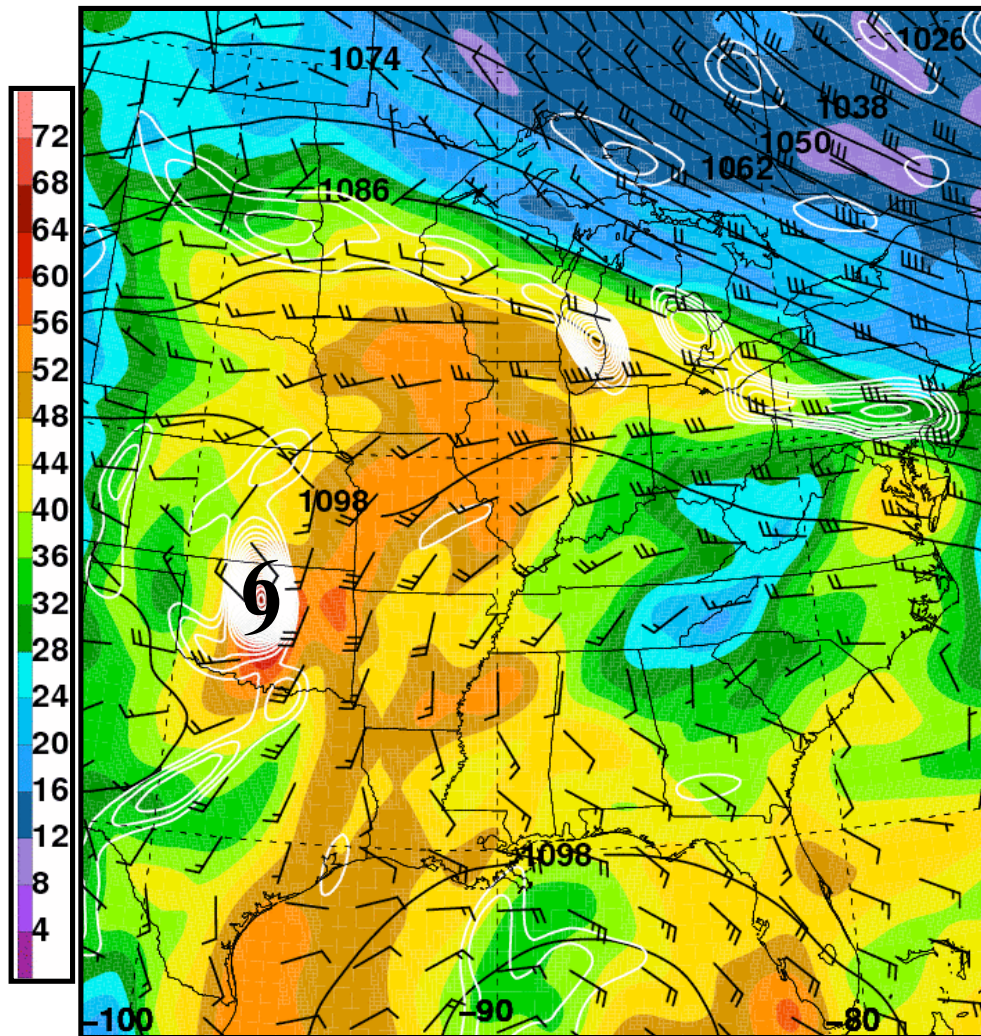


850 hPa ω (dam), θ (K), wind (kt)
900–800 hPa frontogenesis
[$\text{K (100 km)}^{-1} (3 \text{ h})^{-1}$]

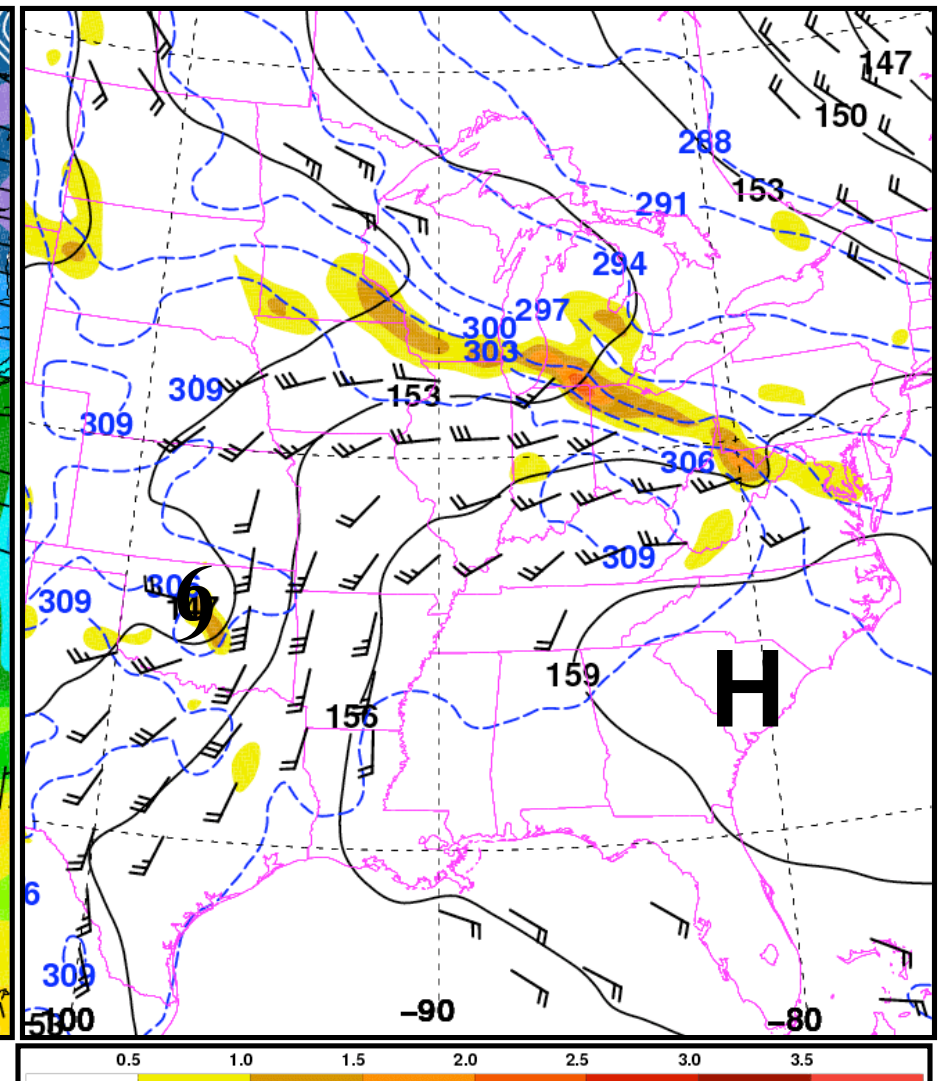


0600 UTC 19 Aug 2007

250 hPa ω (dam), 700 hPa ζ (10^{-5} s^{-1}),
precipitable water (mm)
850–500 hPa mean wind (kt)

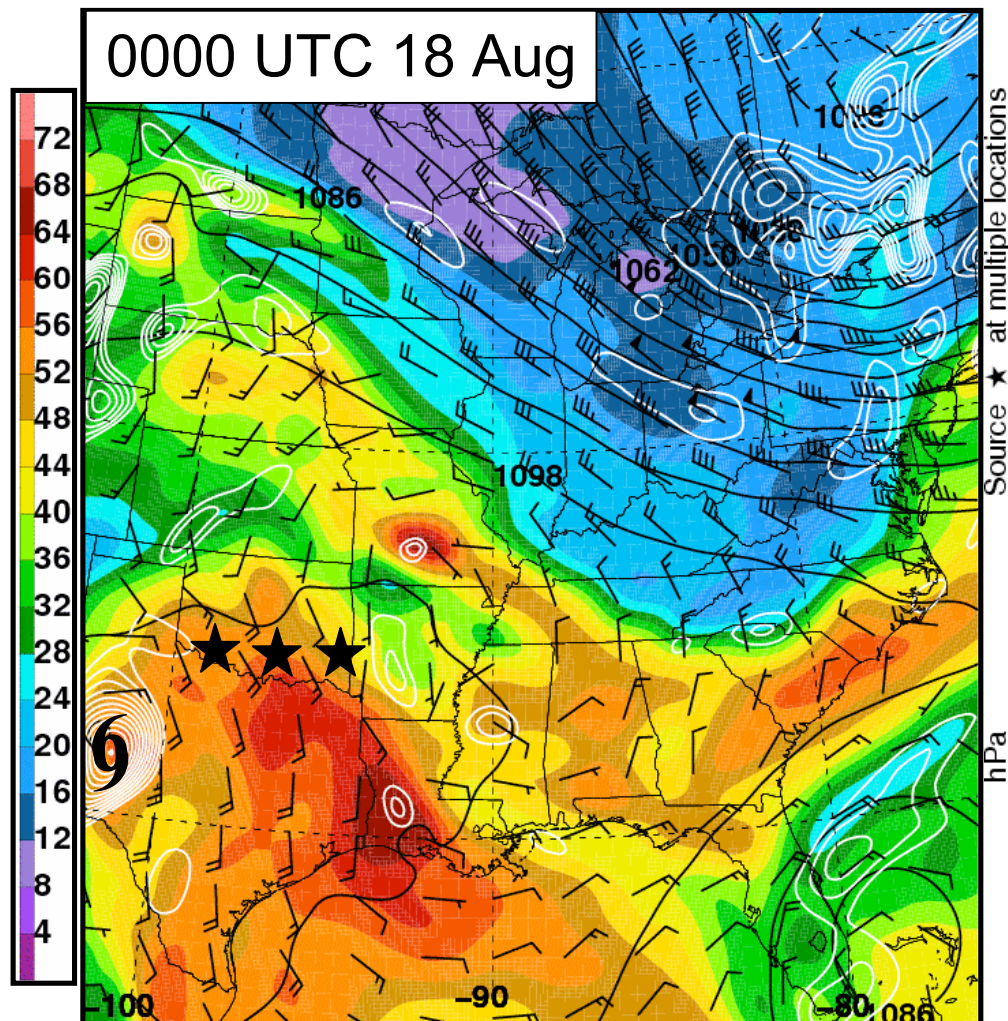


850 hPa ω (dam), θ (K), wind (kt)
900–800 hPa frontogenesis
[$\text{K (100 km)}^{-1} (3 \text{ h})^{-1}$]



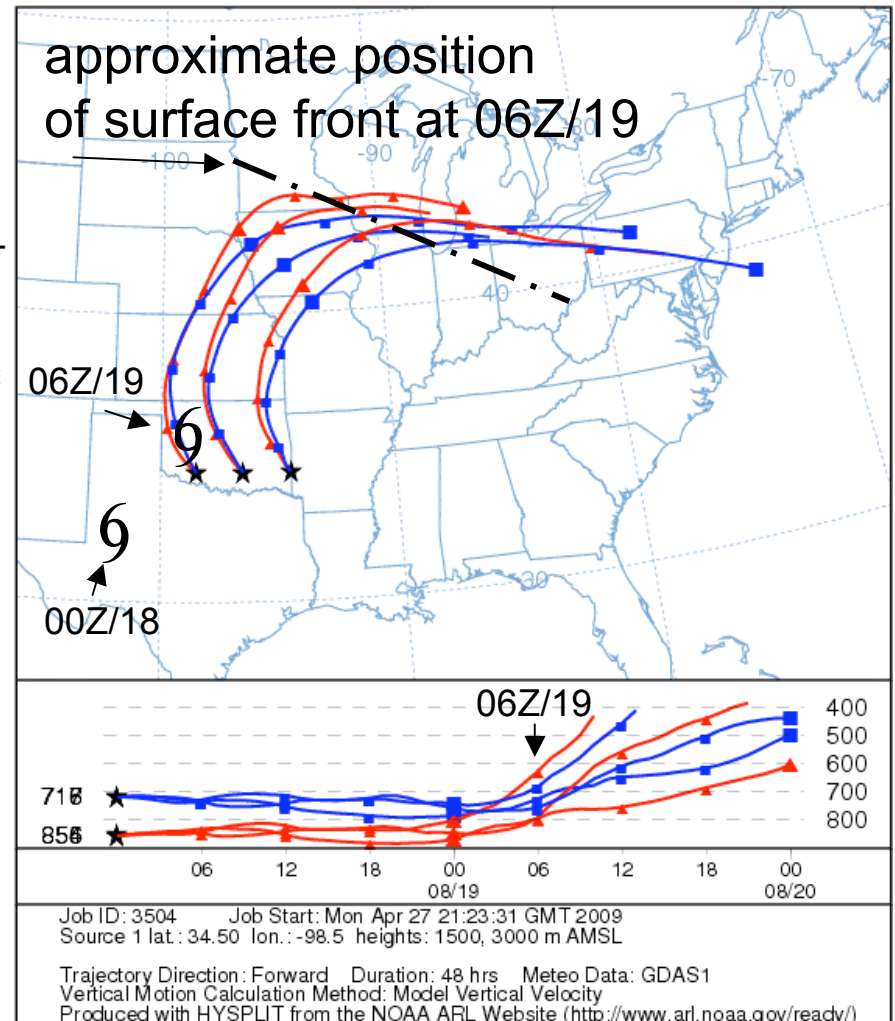
1200 UTC 19 Aug 2007

250 hPa h (dam), 700 hPa ζ (10^{-5} s^{-1}),
precipitable water (mm)
850–500 hPa mean wind (kt)



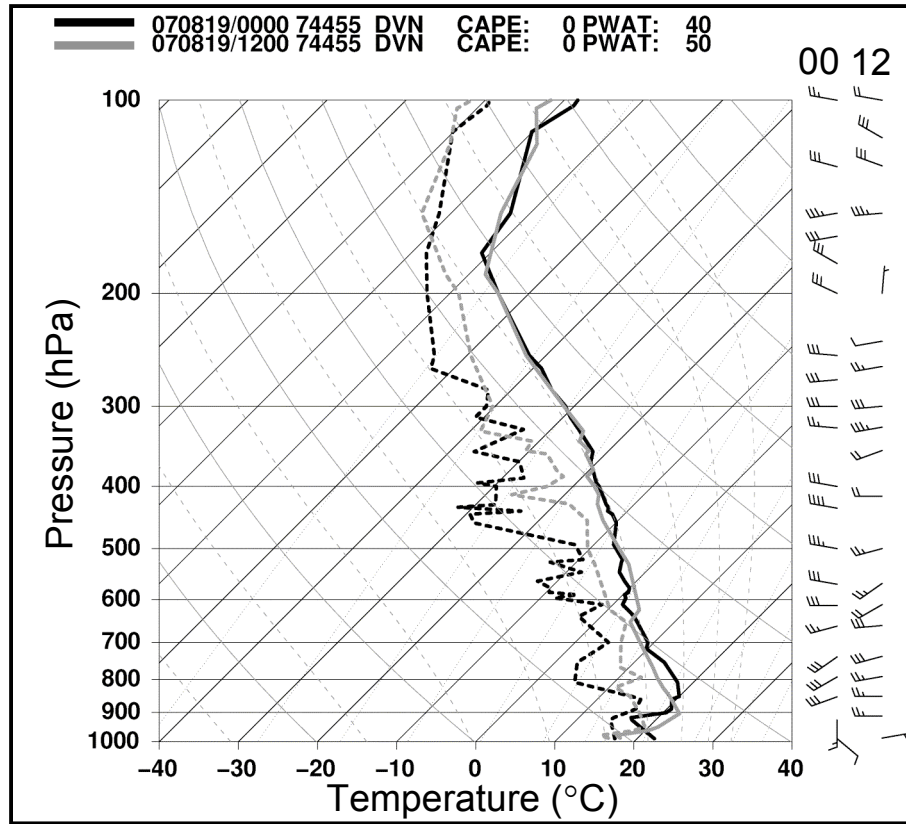
Air Parcel Trajectory Analysis

NOAA HYSPLIT MODEL
Forward trajectories starting at 0000 UTC 18 Aug 07
GDAS Meteorological Data

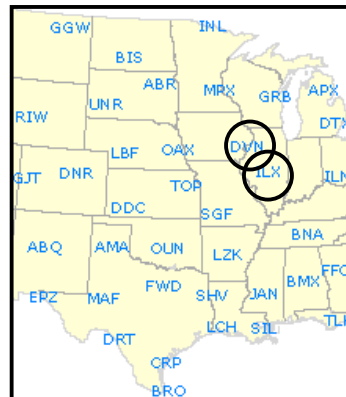
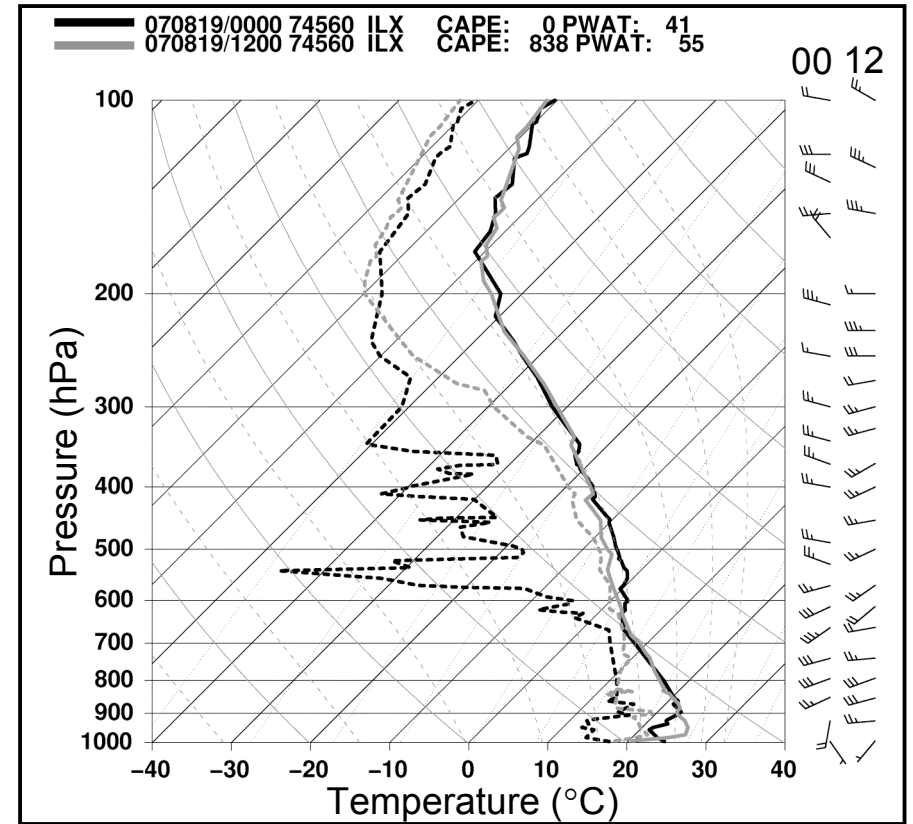


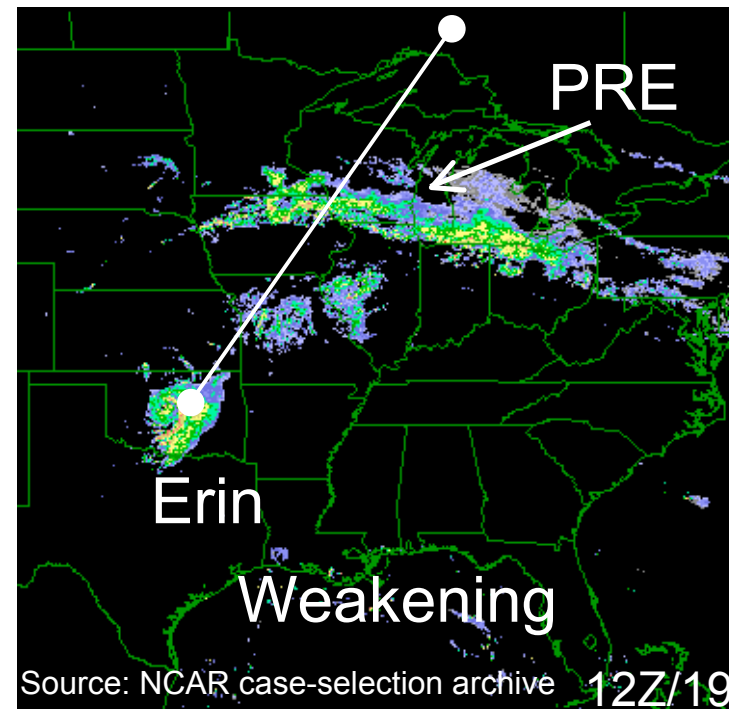
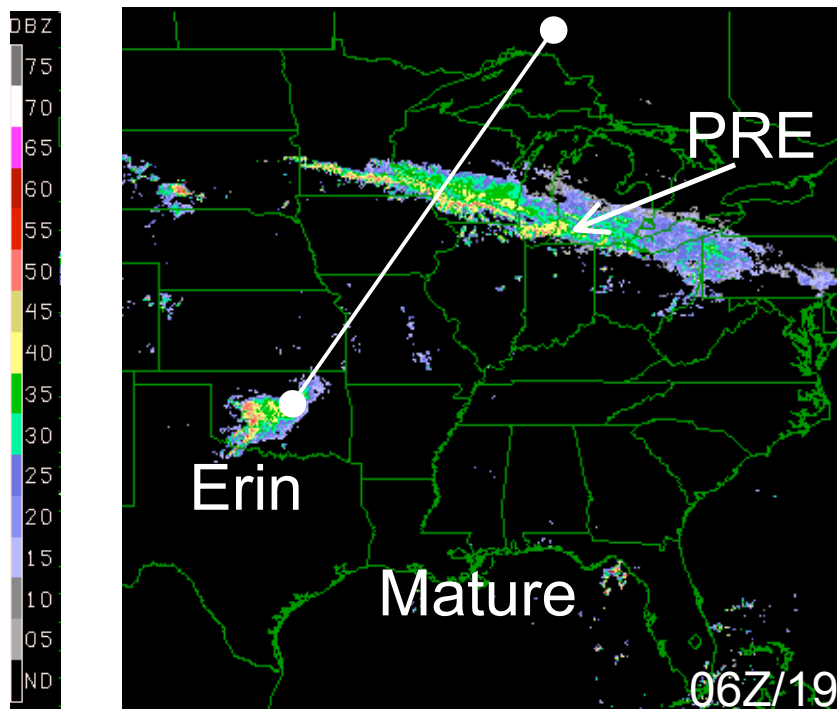
- Air parcels originating in the Erin moisture plume reach the PRE region by 0600 UTC 19 Aug (mature stage)

DVN sounding at 0000 and 1200 UTC 19 Aug

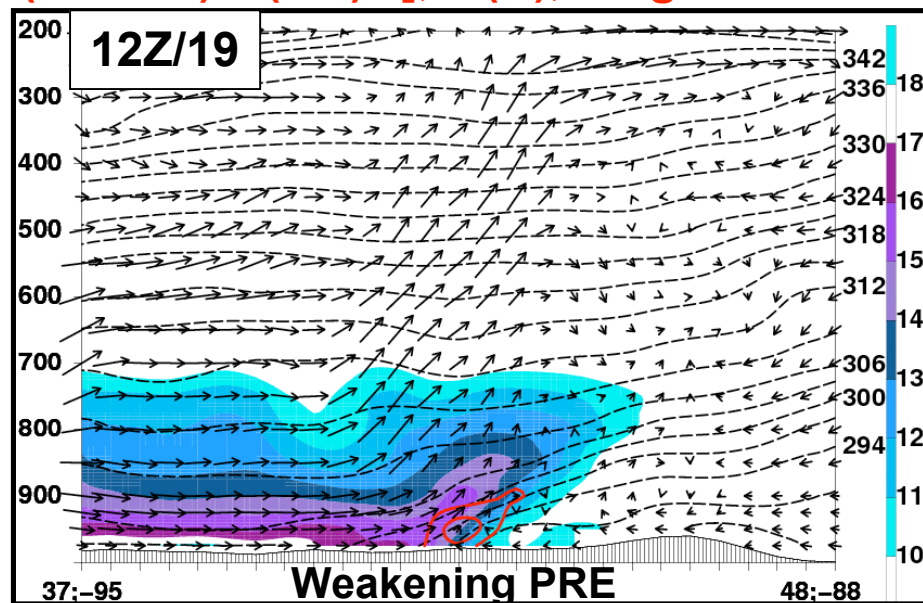
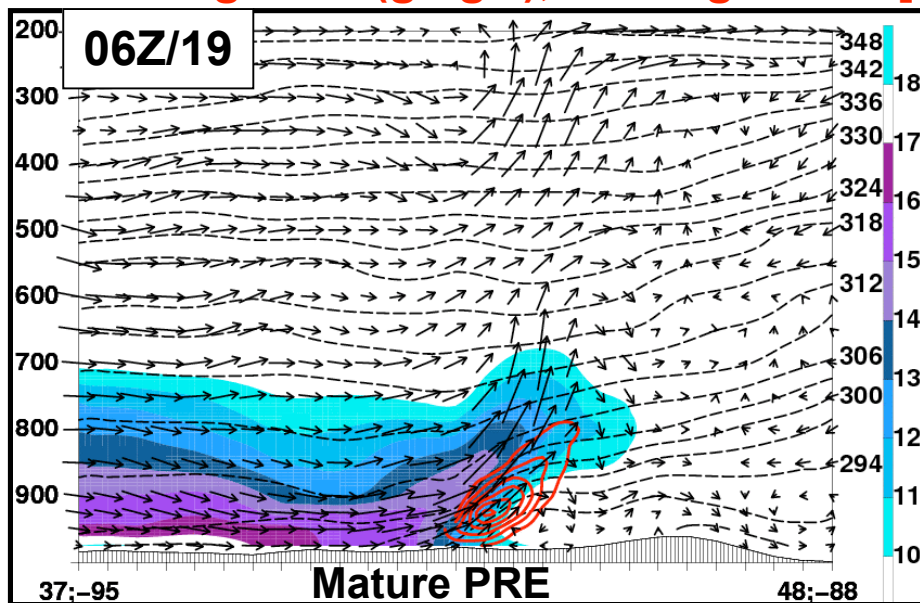


ILX sounding at 0000 and 1200 UTC 19 Aug





Mixing ratio (g kg^{-1}), frontogenesis [$\text{K (100 km)}^{-1} (3 \text{ h})^{-1}$], θ (K), tangent flow



Concluding Remarks I

- Widespread rains > 250 mm fell during 0000–1200 UTC 19 Aug over Wisconsin and the southern Great Lakes region
- Deep tropical moisture transport from TS Erin enhanced precipitation rate
- TS Erin PRE occurred in region of focused ascent over and north of baroclinic zone within equatorward jet-entrance region

Concluding Remarks II

- Poleward advection of moisture likely aided by strong low-level southerly flow east of TS Erin
- Strong low-level southerly flow driven by increasing height gradient between TS Erin and strengthening ridge over southeast U.S.
- Low-level frontogenetical forcing maximized during overnight hours and provided a focus for vigorous ascent during mature stage of PRE

Concluding Remarks III

- PRE intensity and longevity is primarily governed by:
 - the poleward transport of tropical moisture by the synoptic-scale flow
 - the ingestion of tropical moisture into the vertical circulation of the low-level frontal boundary